AGRICULTURE'S RESPONSIBILITY CONCERNING

Polychlorinated Biphenyls (PCBs)

U.S. Department of Agriculture

Report Prepared

by

U.S. Department of Agriculture Ad Hoc Group on PCBs

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PREFACE

The inadvertent contamination of a fish meal with polychlorinated biphenyls (PCBs) from a leaky heat exchanger and the subsequent contamination of poultry feeds in several southeastern States resulted in an acute awareness of the present and future problems posed by these persistent compounds. Accordingly, the Director of Science and Education, USDA, established the Ad Hoc Group on PCBs on August 30, 1971, to address itself to the problem as it relates to agriculture.

The members of the USDA Ad Hoc Group are Robert C. Riley (CSRS), Chairman; Gerald F. Combs (S&E), Executive Secretary; Theodore C. Byerly (S&E); Fred Dunn (AMS); Calvin Golumbic (ARS); Harry W. Hays (ARS); George Mountney (CSRS); John E. Spaulding (APHIS); Fred H. Tschirley (S&E) and Bill G. Tweedy (CSRS).

The report on "Agriculture's Responsibility Concerning PCBs" has been developed by this group with Jane A. Taylor's (S&E) technical assistance. Since the PCB problem constitutes the first example of a widespread environmental hazard from an industrial chemical not classed as a pesticide, it is believed that the study of this problem may be helpful in identifying and coping with the hazards of other industrial chemicals, especially as related to the protection of our food supply.

On September 1, 1971, an Interdepartmental Task Force also was created to conduct a study on PCBs. This task force is coordinated by the Office of Science and Technology and the Council on Environmental Quality and includes representatives from USDA, Environmental Protection Agency, Food and Drug Administration, National Institute of Environmental Health Sciences, Department of Commerce, and the Department of the Interior. The USDA members of the Interdepartmental Task Force are Harry W. Hays, John E. Spaulding, and Bill G. Tweedy.

The interdepartmental 6-month study has been completed and a report compiled entitled "PCBs and the Environment." In conjunction with this study, the NIEHS organized a meeting on PCBs on December 20-21, 1971. The proceedings of this meeting are available. In addition, the Hazardous Chemicals Task Force of the Council on Environmental Quality has prepared a draft report on PCBs. These sources of information have been drawn upon heavily by the Ad Hoc Group in the preparation of this report.

In order to identify the extent of PCB research activities in Agriculture, a questionnaire was sent to State Agricultural Experiment Stations, Schools of Forestry, Pesticide Residue Regional Projects Technical Committee, and the Agricultural Research Service. Approximately 10 scientist man-years and 12 support man-years are involved in this research effort at 31 different laboratories. Most of the work is concerned with residue and analytical methodology. The results of this survey are appended.

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SUMMARY

AGRICULTURE'S RESPONSIBILITY CONCERNING PCBs

Polychlorinated biphenyls (PCBs) are a group of industrial chlorinated hydrocarbons that have caused widespread environmental contamination. They have been used as dielectric fluids in transformers and capacitors as well as for a multiplicity of less essential uses over the past two decades. Despite the widespread use and distribution of the PCBs, they were not detected as environmental contaminants until 1966 by scientists in Sweden. Monitoring efforts in this country since 1967 have revealed PCBs in milk, eggs, meats, fats and oils, and cereal products. They have directly and indirectly found their way into animal feeds and animal food products through water, paints, heat transfer fluids, and plastic and cardboard food-packaging materials. PCBs are fat soluble and persist and accumulate in oil and fat. The combination of persistence and accumulation during transition through the food chain can result in considerable magnification. PCBs are known to be harmful to chickens, ducks, mink, fish, and wildlife; and synergistic effects of PCBs and certain pesticides have been reported. Background levels being observed in remote areas suggest that the persistent chemicals will be of concern for many years.

The Director of Science and Education of the USDA established an Ad Hoc Group on PCBs on August 30, 1971, to address the PCB problem as it relates to agriculture. This group has surveyed the work on PCBs in agriculture and has worked with the Interdepartmental Task Force on PCBs. A survey of the effort on the PCB problem in State and Federal laboratories indicated that approximately 10 scientist man-years and 12 support man-years are involved in PCB research at 31 different laboratories. These man-years of effort do not include regulatory functions.

In their report to the Director, the USDA Ad Hoc Group on PCBs recommends action in three areas of specific concern to agriculture:

(1) The PCB milk contaminant problem originating from silos painted with PCB paints or sealants should receive concentrated attention to dispose of the source of contamination.

(2) The PCB feed contaminant problem requires the express concern and attention of Agriculture. Emphasis should be placed upon all types of fat-soluble contaminants in feeds. A system of surveillance is recommended to detect residues of fat-soluble contaminants in feeds and feed ingredients. The accidental contamination of animal feed by PCBs has imposed without warning an environmental, economic, and psychological burden upon the agricultural community. New and old sources of contamination and accidental spillages must be detected and corrected at early stages of a problem.

Agriculture should place maximum emphasis on minimizing residues in feeds to curtail the possibility of biological magnification in animals.

(3) Agriculture must continue to contribute to solving methodology problems and to the general pool of knowledge concerning a contaminant such as PCBs. Specific areas such as synergism, biodegradation, and uptake by plants are closely related to Agriculture's role. Further, Agriculture needs the flexibility to react swiftly to meet rising needs by mobilizing the entire agricultural community.

The above areas are in addition to and in support of the actions of the Interdepartmental Task Force coordinated by the Office of Science and Technology and the Council on Environmental Quality.

The Interdepartmental Task Force on PCBs recommended in May 1972 that only essential uses of PCBs, in electrical capacitors and transformers, be continued. Action to be taken by the member agencies includes:

(1) Restrict the discharge of industrial effluents of PCBs from PCB users so that levels of PCBs in rivers and lakes do not exceed 0.01 parts per billion (EPA).

(2) Propose new regulations for more stringent action levels for PCBs in foods to prevent PCB contamination from food packaging materials and to prevent contamination of food from accidents in food plants (FDA).

(3) Support the Toxic Substance Control Act pending before Congress. Additional regulatory authority is needed to control the use and distribution of PCBs, to control imports, and to collect information.

I. Introduction

A. Physical Properties

The polychlorinated biphenyls (PCBs) are a group of chlorinated hydrocarbons widely used as industrial chemicals. The commercial products contain approximately 50 of the 210 different compounds which are theoretically possible when biphenyl is chlorinated. The most common mixtures contain between 40 and 60 percent chlorine. The complex mixture of isomers is identified by the percent of chlorine by weight in the total product; e.g., Aroclor 1254 contains 54% chlorine.

The physical properties of PCBs vary with the chlorine content. Those with low chlorine content are fluid liquids and those with high chlorine content are highly viscous liquids. The low chlorine containing mixtures are clear in appearance, but those containing 50% or more chlorine are light yellow. All PCBs have a very low solubility in water. Volatility is low and decreases with increases in chlorination. They are stable in water and are not easily subject to acid or alkaline hydrolysis. These characteristics cause them to be quite persistent to chemical and biological degradation in the environment and this results in environmental and biological contamination.

B. Uses of PCBs

Because of their high flash point and inertness, PCBs have been widely used as dielectric fluids in capacitors and transformers, hydraulic fluids, and heat transfer fluids. Since 1963 more than 50 minor uses have been cited in CHEMICAL ABSTRACTS. These include plasticizers and solvents in adhesives, printing ink, sealants, moisture retardants, paints, and as pesticide carriers.

1. Production of PCBs

Since their introduction in 1930, the use of PCBs in the U.S. steadily increased to 34,000 tons by 1970, but has fallen off in 1971 to 20,000 tons. The cumulative production over the years is estimated at 500,000 tons. Monsanto Company is the sole producer of PCBs in the U.S. under the trade name of Aroclor. PCBs are also produced in Europe, Japan, and U.S.S.R. The manufacturers in foreign countries producing PCBs can be identified, but their total production is unknown.

2. Substitutes for PCBs

The best substitute for PCBs when being used for dielectric fluids is mineral oil; but because of its low flash point,

it cannot be used where there is a possibility of fire hazard. The fluorocarbon liquids can be used, but the transformers require a special design. Few fluids have a comparably high dielectric constant and lend themselves as suitable substitutes. Solid state circuitry is another possible substitute and greatly reduces the need for PCB-containing capacitors. Dry transformers can be used but are much larger and more expensive.

The function of PCBs in the heat exchange and hydraulic fluids is primarily to reduce the fire hazard. Substitutes for heat exchange and hydraulic fluids are a chlorinated biphenyl-phosphate ester-petroleum hydrocarbon blend, a mineral hydraulic oil, and aromatic chlorides. The mineral hydraulic oil increases flammability and also results in formation of emulsions. The aromatic chlorides are poor substitutes for the PCB and could also result in an undesirable effect upon the environment. We have been informed that PCBs have not been used in hydraulic fluids since early 1971, and currently, no chlorinated hydrocarbons are used in hydraulic fluid formulations.

PCBs as plasticizers have been replaced largely by the phthalate esters. These compounds appear to be very desirable substitutes and are destroyed upon burning; whereas, the PCBs will result in environmental contamination unless the temperature exceeds 800°C. Phthalate esters are known to be toxic, from rat studies, but at much higher levels than for PCBs.

C. Distribution in the Environment

Despite the fact that PCBs have been available for 40 years, they were not detected as environmental contaminants until 1966 in Sweden and 1967 in the U.S. In the spring of 1967, Monte Kirven of the San Francisco Natural History Museum was searching the Northwest for peregrine falcons. One single, unhatched egg was brought to a laboratory and analyzed for DDT. The egg was found to contain 5 mg. of DDT and other related products which could not be identified. Because of the importance of the peregrine falcon, an attempt was made to identify the related, unknown compounds. Widmark (1967) had reported that a chlorine-containing compound was present, and its properties were similar to DDT. These similarities created a problem in isolation and identification of residues of DDT. Using this information and additional results, the unknown compounds were identified as polychlorinated biphenyls. These

same compounds had been observed in the analysis of other species of birds and fish. Subsequently, the PCBs have been found to be almost ubiquitous in the world ecosystem.

The exact nature of PCB entry into the environment is not understood, but scientists have speculated on possible major sources. Sewage outfalls and industrial disposals into waterways are two principal means of entry. It is estimated that 4,000 tons per year enter waterways from dumpage and leakage of lubricants, hydraulic fluid, and heat transfer fluids. Residues are present in water, sewage sludge, and bottom sediments. Levels in water are usually less than a part per billion; in sewage and sediments, tens to hundreds of parts per billion; and in sewage sludge, a few parts per million.

Although discharges into the rivers and streams appear to be the primary routes into the environment, atmospheric discharges also appear to be a major means of entry. It has been estimated by Adel Sarofim of MIT that approximately 1,500 tons have escaped into the atmosphere thus far from burning plasticized materials containing PCBs. Burning of PCB-containing materials results in volatization of PCBs in the atmosphere unless the temperature exceeds 800°C. Some of the oxides, such as dichlorobiphenylfurans and dioxenes, formed from partial oxidation, are more toxic than the parent materials. PCBs can escape through ventilation and exhaust systems at the point of manufacture and the plants where PCB products are processed. PCBs have been found in rain and in airborne particulates in the United States and in snow collected in Sweden. The levels found in these studies were in insufficient quantities to determine the specific levels.

In a study by the Michigan Department of Public Health, almost 50% of the samples of human adipose tissue received contained at least 1 ppm of PCB (Price and Welch 1971). One source of contamination to man is via the birds and mammals which have fed on contaminated fish or other contaminated foods. Another route is through residues on foods which have been wrapped in papers and plastics containing PCBs. A third route is through milk from cows which have been fed silage from silos coated with PCB-containing paint.

Despite the chemical inertness of PCBs, chemical changes occur in the environment. Safe and Hutzinger (1971) showed that 2,2′,4,4′,6,6′-hexachlorobiphenyl when irradiated at 3100 Å in hexane and methanol solutions lost chlorine atoms, and rearrangement and condensation products occurred. Safe and Hutzinger recently reported that relatively large amounts of dechlorinated compounds are formed when the commercial PCBs are irradiated in vapor phase, aqueous

suspensions, hexane, methanol and aqueous dioxane solutions and, with this, films of undiluted material. They speculated that the degradation products were hydroxychlorobiphenyls and carboxylic acids and that the hydroxychlorobiphenyls are probably intermediates in the formations of chlorodibenzofurans.

D. Toxicology of PCBs

1. General

Of particular importance in considering the toxicology of polychlorinated biphenyls is the fact that the commercial preparations are mixtures of compounds having different degrees of chlorination. Since each product may contain many different isomers in varying proportion, they may also show very different properties and degrees of toxicity.

Two features common to both PCBs and organochlorine insecticides are their persistence and accumulation in oil and fat. This combination of persistence and accumulation during transition through the food chain can result in considerable increase in concentration of these compounds. For example, shrimp exposed to 10 ppb of Aroclor 1254 for 48 hours accumulated 1300 ppb of PCBs.

Toxicity studies on birds, using several different PCB formulations, indicate that the toxicity increases with the percentage of chlorine, except in studies with Leghorn chickens. Bobwhite quail were the most sensitive to PCBs, followed by pheasants and mallard ducks. The oral administration of PCBs to chicks and quail produces chemical porphyria, hydropericardium, abdominal edema, liver necrosis, and dilation of the kidney tubules. The rate of estradiol metabolism is greatly increased in pigeons after PCB treatment which may indicate induction of hepatic hydroxylases. Poor hatchability with decreased egg production and thinning of egg shells has been observed with most of the commercial preparations. There is, however, considerable species variation.

Information concerning the effects of PCB residues in fish or the possible hazard posed by such residues has not been determined. Recent studies indicate that PCBs have a relatively low toxicity in trout and bluegills while shellfish, oysters, and shrimp are many times more sensitive.

Acute oral, dermal, and vapor exposure studies in mammals would indicate that the acute toxicity of PCBs is not a significant factor in evaluating the potential health hazard. The oral LD_{50} for products containing 21 to 68 percent chlorine is in the range of 4 to 10 grams per kilogram.

Laboratory studies with rats, rabbits, guinea pigs, and mice have shown that ingestion, skin absorption, or inhalation of PCBs may give rise to liver necrosis, hyperplasia, and hyperkeratosis of the follicular epithelium, and hydropic degeneration of the convoluted tubules. Chemical porphyria has been observed in most species.

McCune et al. (1962) observed that an epoxy-resin paint containing Aroclor 1242 caused symptoms of "chick edema" when chicks were placed in a freshly painted battery brooder. Subsequent studies with levels from 100 to 800 ppm showed that this PCB mixture caused labored respiration, accumulation of abdominal fluids, enlarged heart, hydropericardium, swollen kidneys, and hemorrhage of internal organs. Mortality was increased and weight gains reduced.

Further studies by Flick et al. (1965) suggested that 400 ppm were required to produce serious symptoms. They observed cream-colored pancreas, enlarged adrenals, small spleen, dermatitis, loss of feathers, low hemoglobin, low hematocrit, and reduced blood glucose.

Recent studies on several commercial polychlorinated biphenyls of foreign manufacture have shown the presence of tetra- and pentachlorodibenzofuran and hexachloronaphthalene which presumably occurs during manufacturing. A single oral dose of 0.5 to 1.0 mg/kg of these chlorinated dibenzofurans produces liver necrosis and chloracne in rabbits (Vos et al. 1970). The evaluation, therefore, of PCBs on the basis of effects and residues in test animals is made extremely difficult because of the difference in toxicity between various isomers and the presence of biologically active contaminants.

Approximately 10 cases of fatal intoxication have been reported among industrial workers who handled or were exposed to chlorinated biphenyls or naphthalenes. Histopathologic examination revealed liver necrosis and cirrhosis (Drinker et al., 1937; Flinn and Jarnick, 1936; Greenburg et al., 1939). In 1968, six hundred persons were poisoned in Japan after consuming rice oil that was highly contaminated with a polychlorinated biphenyl, Kanechlor 400. The clinical effects included chloracne, visual

disturbances, jaundice, numbness, and spasms. Newborn infants from mothers, who had been poisoned, showed discoloration of the skin which regressed after 2 to 5 months. From the Japanese incident, it was estimated that the minimum dose for producing positive clinical effects in man is 500 mgs.

2. Effect on Wildlife

Existing data suggest that one of the principal routes of PCBs through the environment is from waste streams into receiving waters, downstream movement in the water and on sediment, accumulation from the water of PCBs by aquatic organisms, and transfer to birds and mammals through residues in fish that are eaten. The toxicological and environmental PCB residues in fresh water fish and invertebrates were reported by Stalling and Mayer (1972).

In simple food chains, fish to eagles or fish and mussels to seals, concentrations of PCBs increase by thousands of times from prey to predator (Jensen et al., 1969).

The toxicity of PCBs increases when the organism is under stress. In addition, PCB exposure will stress an animal to increase the susceptibility to other mortality factors. For example, mallard ducklings exposed for 10 days to a dietary dosage of 25, 50, or 100 ppm of Aroclor 1254 showed 35 to 44 percent mortality upon subsequent exposure to duck hepatitis virus; whereas, mortality among birds exposed only to the virus was 14 percent (Friend and Trainer, 1970).

Behavioral differences have also been observed with high dosages of PCBs, as in poor choices of visual cliff tests in pheasants (Dahlgren and Linder, 1971) and migratory restlessness in Swedish robins (Ulfstrand and Sodergren, 1971). These behavioral differences could influence the avoidance of danger and the survival of the species.

It is apparent that the evaluation of the effects of PCBs in the environment is hampered by the complex nature of the PCB mixtures, by the inclusion of contaminants in the mixtures, and by the interactions with similar compounds such as DDT and with other stress factors. In addition, experimental studies are being conducted with the unaltered products as they are manufactured. The results may not properly reflect the effects of the components as they exist in the environment.

3. Synergistic Effect With Pesticides

Limited information is available concerning the synergistic effects of PCBs with pesticides. Sublethal dosages of several

Aroclors increased the toxicity of dieldrin and DDT to Drosophila and houseflies (Lichtenstein et al., 1969). Aroclor 1254 increased the toxicity of carbaryl to houseflies by factors of 11- to 82-fold (Plapp, F.W., 1972). The mechanism of synergism is unknown. If synergism related to PCBs occurs with other insecticides and with mammals as well as with insects, then unintentional exposure to PCBs due to environmental contamination may have significant implications to nontarget organisms exposed to combinations of PCBs and pesticides.

II. Agriculture's Responsibility in Cooperation with Other Agencies

American agriculture, historically, has prided itself on the production, processing, and marketing of an ample supply of high quality foods, not only for use in this country, but in foreign countries as well. The successful development of American agriculture has been unparalleled in its continued application of science to achieve greater productivity and efficiency. This has included the widespread use of fertilizers, pesticides, antibiotics, hormones, and many other feed and food additives. The potential hazards associated with each of these have been generally recognized, and suitable control measures are being instituted to provide a wholesome food supply without polluting the environment. Contamination of food by industrial chemicals such as PCBs must also be avoided. Development and application of appropriate technology to meet new problems such as the PCB problem require directed efforts in research, education, and regulatory roles.

The USDA not only is concerned with the support of research and Extension activities to help agriculture develop and apply the technology needed for efficient production of high-quality, wholesome foods, but is charged with the plant inspection of meat, poultry and egg products.

The Wholesome Poultry Products Act of 1968, the Wholesome Meat Act of 1967, and the Egg Products Inspection Act of 1970 all require that the responsible agencies within the USDA through monitoring, certification requirements, or testing prevent adulterated meat, poultry, or eggs from being traded in commerce. The definition of adulteration is similar in all three Acts. Each Act contains, as part of the adulteration definition, the following: "...if it (the respective product) bears or contains any poisonous or deleterious substance which may render it injurious to health; but in case the substance is not an added substance, such article shall not be considered adulterated under this clause, if the quantity of such substance in or on the article does not ordinarily render it injurious to health." In the case of an industrial chemical contaminant such as PCBs, the determination of the level which is injurious to health is a Food and Drug Administration responsibility.

According to the Interdepartmental Task Force Report, the Federal Government has taken several new actions to deal with the PCB problem. The Environmental Protection Agency has measured PCBs in sewage sludge and water. This agency will prohibit industrial effluents from contaminating water, and a maximum level of 0.01 ppb has been established for PCBs in rivers and lakes. New regulations proposed by FDA have new and more stringent action levels for PCBs in food; steps to prevent PCBs in food-packaging materials; and measures to prevent accidental contamination of food, including animal feeds. The Department of the Interior and the Department of Commerce have followed the levels in fish and certain birds.

Although this vast effort appears to be reasonably comprehensive, it should be recognized that almost all of it was initiated after the problem existed, and that even now legislative authority is needed in certain areas of control. There is no broad Federal authority at present to restrict the use or distribution of PCBs, to control imports, or to collect information. The Toxic Substances Control Act now pending before the Congress would provide such authority.

III. Special Concerns in Agriculture

PCBs must be considered as potential contaminants in several components of agricultural systems. They have found their way into animal feeds and animal food products. Since PCBs are fat soluble, they may be recycled in animal byproducts and concentrated in animal wastes. Paper and cardboard food-packaging materials also may be contaminated. PCBs have been found in milk, eggs, meats, fats and oils, and cereal products. PCBs are known to be harmful to chickens, ducks, mink, fish and wildlife; and synergistic effects of PCBs and certain pesticides have been reported. Background levels being observed in remote areas suggest that these persistent chemicals will be of concern to agriculturists for many years to come.

A. Contamination of Animal Feeds

1. General

The accidental contamination of animal feeds with PCBs has been responsible for most of the inadvertent contamination of foods for man. PCB contamination of animal feeds has been traced to heat transfer exchange fluids, hydraulic fluid, plastic wrappers, paints and sealants used on silo walls and in feed troughs, and misused transformer fluid in a herbicide spray. The identified feed sources of PCBs have consistently been the result of inadvertent contamination of a feed ingredient with a PCB mixture or migration from a feed contact surface. Generally, the PCB residue in the feed has been lower

than that found in adipose tissue of the animals which consumed it. Animals with a prolonged feeding period, such as laying hens and dairy cows, are more at risk than broiler chickens and pigs which consume less feed per unit of body weight.

In April 1970, PCB contamination was caused by transfer of PCBs from silo wall coatings to silage. Cows fed this contaminated silage excreted the PCBs in their milk. Another incident, in three New York counties in February 1971, involved laying hens producing eggs containing PCBs. The suspected feed ingredient was a "bakery byproduct" contaminated with PCBs from plastic wrappings.

In late summer, 1971, the inadvertent PCB contamination of fish meal used in poultry feeds led to an extensive problem. The fish meal had become contaminated with heat exchange fluid during pasteurization to destroy Salmonella. This incident affected the entire poultry industry in the southeastern United States and required control efforts in eleven States. Soon after this incident occurred, a turkey flock in Minnesota was found to be contaminated with PCBs and required a special surveillance program. The suspected source was hydraulic fluid used in oil meal presses.

Quite apart from the accidental contamination of animal feed ingredients, the widespread distribution of PCBs provides a basis for concern about their biological magnification as they move through the food chain. For example, fish and aquatic invertebrates have been shown to accumulate PCBs to levels 75,000 times that present in water and frequently contain from 1 to 10 ppm. The levels which are reached also depend on the length of exposure to PCBs. In rats fed a laboratory chow containing 0.05 to 0.1 ppm of PCBs, a 50-fold increase in level in the adipose tissue has been observed. Scott et al.(1971) reported a 4- to 6-fold increase in adipose as compared to diet levels in laying leghorn hens in only 8 weeks.

Animal products generally contain higher levels than do plant products when background levels are considered. Feed ingredients most likely to contain significant levels of PCBs would include fish products, animal byproducts, and animal fats.

The Food and Drug Administration conducted a survey on the PCB content of complete animal feeds. Levels of PCBs in 1274 mixed feed samples were analyzed with results indicating 4.4% of positive samples and with positive levels ranging from 0.1 ppm to 0.6 ppm.

A previous FDA pesticide surveillance program for FY 71 and 1st quarter of FY 72 showed the following levels of PCBs in various feeds and feed components:

Product	No. Samples 1/	Percent Positive	Range of Positive (ppm)
Hays, natural	104	1	-
Hays, dehydrated	46	0	-
Silage	81	2.7	0.15-1.12
Grain, whole	105	0	-
Grain, ground	50	4.0	T-0.32
Cereal byproducts	43	0	-
Oilseed byproducts	41	0	-
Animal byproducts	25	8	1.08-1.32
Fish byproducts	23	35	0.2 -5.0

1/ Includes imports.

2. PCB-Containing Paints and Sealants

This problem was identified originally when the Ohio State Department of Agriculture detected PCB residues in milk samples from the Cincinnati milkshed. They traced the contamination to the walls of concrete stave silos which had been painted with PCB-containing paint. PCBs have also been used in silo sealants. Contaminated silos have since been reported in Kentucky, Tennessee, North Carolina, West Virginia and Pennsylvania; but information about the number of contaminated silos on a national basis is lacking.

Prior to 1968, one of the paints used to coat the interior of concrete-stave silos contained Aroclor 1254. In two areas, centered in Ohio and Kentucky, builders coated the entire interior walls of the silos; and in Tennessee, the material was only used to seal the joints between the staves.

Field studies by the Animal Science Research Division (ASRD), ARS, and the regulatory experience in Ohio and Kentucky suggest that if a dairyman has a silo with the entire wall coated, the residue levels of PCB will be in the range of 10-15 ppm in milk fat at the time silage is fed. The FDA-proposed guideline for PCB residues in milk is 2.5 ppm in milk fat. Invariably, a dairyman with PCB-contaminated silos will produce milk exceeding the guideline for at least that part of the year when silage is fed. Milk from four farms in Tennessee where only the silo joints were coated with PCB-containing paint has been examined by ASRD. The residue levels were about 5 ppm in milk fat when silage was being fed.

The Aroclor 1254 residues in silage occur mainly within 2 or 3 inches of the silo wall. As one progresses down the silo, it is possible to detect small amounts of PCB several feet from the wall. The levels of PCBs found in silage have ranged from 3.4 to 31 ppm within 4 inches and from 0.1 to 0.27 ppm from 6 to 24 inches from the wall (Skrentny et al. 1971).

In addition to paints and sealants for silos, PCB-containing paints, putties, and water-proofing compounds have been used on animal feed troughs and other surfaces. In one instance where a feed trough for swine was coated with a sealant containing Aroclor 1254, chips from the bottom contained 8000 ppm PCBs. Similarly finished feed transported in a newly painted hopper car contained 6.5 ppm of Aroclor 1248.

3. Plastic Materials

The PCB contamination of eggs from laying hens in New York State, which led to the incrimination of a bakery byproduct meal used in the laying mash, is an example of PCB contamination from plastic wrappings. It appears that the amounts of these materials ground up with the bakery byproducts were sufficient to explain the PCB contamination.

4. Heat Transfer Exchanger Fluids

PCBs have been used extensively as heat transfer exchanger fluids because of their high flash points. Leaks on a hot surface or into a furnace present a fire hazard with

flammable heat transfer fluids. Where PCBs have been used, this danger has been avoided in the past. This accounts for the widespread use of PCBs in heating systems used to process or sterilize feed and food ingredients.

The largest of the PCB incidents which occurred was caused by chicken feed containing imported fish meal that had become contaminated with heat exchange fluid during pasteurization to assure Salmonella control.

In some instances, water can be used as a satisfactory substitute at moderately high temperatures. Some hydrocarbons are now being used as heat exchanger transfer fluids, but these present fire hazards in high temperature systems.

In replacing PCBs with another material, caution should be exercised to avoid spillage and contamination of the environment where food or feed is processed. Spillage can result in heavy contamination of grease-trap fat, which sometimes is used in feed-grade animal fats. All PCBs removed from such systems should be buried or returned to the Monsanto Company where they can be burned in a special high temperature furnace which will degrade these compounds.

5. Hydraulic Fluids

PCBs have been widely used as hydraulic fluids because they have a high flash point. Presumably satisfactory substitutes are replacing PCBs for this use, but one should suspect their presence in currently used equipment.

Hydraulic systems are frequently used on farms, in processing plants, in feed mills, and throughout the entire agribusiness complex. Leaks from hydraulic lifts on feed trucks have contaminated feed.

6. Recycled Animal Byproducts and Wastes

A number of feed ingredients are made from byproducts and waste materials which accrue during processing of animals for human food. These include feed-grade poultry and animal fats, poultry byproducts meal, hydrolized feather meal, meat scraps, meat and bone scraps, tankage, and blood meal. Such products will contain PCBs if the animals

processed were fed a ration contaminated with PCBs. The amount present will depend on: (1) The level in the animal's diet; (2) the amount of contaminated feed consumed per pound of body weight up to the time of slaughter; (3) degree to which ingested PCBs are absorbed; (4) metabolic and bacterial degradation; (5) rate of excretion; and (6) length of withdrawal period, if any, following contamination. The degree of fitness of the animal also may influence the concentration of PCBs in body fat, since they are deposited in the body lipids.

Limited data from rats, growing chicks, and laying hens suggest that 50-90% of the consumed PCBs are not retained, but are rapidly excreted or metabolized.

Studies by Yoshimura et al. (1971) involving radio-labeled Kanechlor given to rats, showed that urinary excretion was limited; but 70% of the dose was in the feces, some of which had been changed to phenolic metabolites. Depletion studies with rats (Curley et al., 1971) confirm the much greater excretion of PCBs in the feces as compared with the urine.

Based on the data of Scott et al. (1971), the proportion of the total PCBs consumed and retained by laying hens in body fat or excreted in eggs has been estimated. These estimates suggest that when the diet contained 1 ppm or less PCBs about 15% of the total PCBs consumed was excreted in eggs and 25% was retained in body fat, leaving approximately 60% to be voided in the droppings or metabolized.

Unpublished data from the Monsanto Company show that Leghorn chickens fed diets containing 1 ppm of Aroclor 1242, 1254, and 1260 from the 12th to 25th week of age, retained 11, 30 and 51% in their body fat. By difference, 89,70 and 49% of the PCBs, respectively, were metabolized and/or excreted. The extent to which the different Aroclors may have been metabolically degraded cannot be determined as the droppings were not assayed for PCBs; however, USDA studies by Cecil et al. (unpublished) reveal that only 10% of ingested Aroclor 1254 was excreted in the feces by laying hens fed diets containing 2 and 20 ppm PCB. Moreover, loss of early peaks in the GLC patterns from egg residues suggested that the lower chlorinated biphenyls were metabolized. Rehfeld et al. (1972) also observed that chicks were able to metabolize the PCBs containing smaller concentrations of chlorine.

Saschenebrecker et al. (1972) recovered only 1.4 and 2% of the total dose in the feces and urine collected from two cows for 7 days, while 4.8 and 7.4% were excreted in the milk over the same period. These limited observations suggest that the ruminant animal may retain or degrade a much higher portion of ingested PCBs than do nonruminant animals.

Recycling of animal byproducts can result in a significant buildup of PCBs in food animals where they are kept for long periods or fed rations containing relatively high levels of PCB-containing animal byproducts. Laying or breeder hens, turkey breeders, dairy cattle, horses, and swine, sheep, or cattle kept for breeding purposes are fed over long periods and consume considerable quantities of feed per unit of body weight before they are slaughtered. Even though none of these would generally be fed rations containing high levels of animal fat or other animal byproducts, the large amount of feed consumed per unit of body fat can result in a considerable magnification of PCB concentration in the body fat as compared to that present in the feed. Animal byproducts from such sources would, however, seldom constitute a major proportion of the total supply.

Most of the feed-grade fat, fish meal, poultry byproduct meal, and other animal byproducts, except tankage, are fed to broiler chickens and growing turkeys with some fed to pigs. Broiler carcasses will seldom contain higher concentrations of PCBs in the fat than were present in the feed fat, although the level in the carcass fat will always be greater than the level on a total feed basis. For example, broilers consume about 2.1 pounds of feed per pound of gain. If the feed contains 0.2 ppm PCBs and 40% is retained in the carcass, the broiler would contain 0.168 ppm (0.2 ppm X 2.1 X 40%). Since broilers average about 12% fat at market weight, the body fat would contain about 1.4 ppm PCBs. Even though this is seven times that in the feed, it would still be slightly less than the PCB concentration in the feed, expressed on a fat basis (2.0 ppm, assuming that the feed contained 10% fat). With turkeys and growing swine, the PCB concentrations in carcass fat would be increased at about twice this rate, since approximately twice as much feed is consumed per unit body weight. Hens kept for commercial egg production or as broiler breeders would consume from 35 to 40 pounds of feed per pound of body weight before marketing and could develop up to 125 times

higher levels of PCB in the body fat than in the feed. Under these conditions, concentrations of PCBs well below the proposed tolerance of 0.5 ppm in the finished feed, could result in levels in the hen which would greatly exceed the 5 ppm (fat basis) tolerance proposed by FDA for poultry.

When significant levels of PCBs are found in animal products, consideration should be given to the consequences of recycling the resulting animal byproduct used in feeds, especially those high in fat. Moreover, a system of surveillance to detect residues of PCBs or other fat-soluble materials should include careful monitoring of recycled animal byproduct feeds and feed-grade fat at the feed ingredient production level.

The possibility of recycling of certain types of animal wastes in feeds for animals is receiving considerable attention. Present information indicates that such waste, if properly processed, can provide a significant proportion of the nutrient needs of ruminant animals. Of course, such wastes must not contain excessive levels of substances such as the PCBs which are potentially harmful to man or animals.

In most cases, digestibility of animal feeds will approach 80% for the grain and concentrate portion of the ration; therefore, if the dietary PCBs excreted in the feces and urine range from 10% (for Aroclor 1254 in laying hens) to 70% (in the rat), the concentration of PCBs in manure on a solids basis could range from a 50% dilution to a 3½-fold increase as compared with the level in the total feed. Even this possible increase in PCB concentration in animal wastes is not likely to constitute a problem in their use in animal feeds where only background levels of contamination are involved and low levels of processed animal wastes used in the total ration for relatively short feeding periods.

With ruminants, however, where higher dietary levels of processed animal waste products can be effectively used and with animals fed for long periods, the possibility exists that the concentration of PCBs in the adipose tissue could easily exceed the tolerance levels proposed. More information is needed, however, about the degradation of PCBs by microorganisms in the rumen. Accordingly, attention to PCB content of such animal wastes <u>must be considered</u> in determining its suitability for recylcing in rations of food-producing animals.

B. Effect of PCBs on Animals and Transfer to Animal Food Products

1. Dairy

Fries (1971) has found that cows fed 200 mgs of Aroclor 1254 daily for 60 days produced milk containing 50 ppm of PCBs in the fat. When PCB feeding was stopped, the level in the milk fat dropped from 50 to 24 ppm in 10 days. Thereafter, the concentration decline was approximately 1% per day. Concentration of PCBs in the milk fat was not related to stage of lactation or level of milk production. Milk from cows fed uncontaminated silage can contain 1 to 2 ppm of PCBs in the milk fat.

Routine surveillance methods in the past have not been adequate to detect PCB levels exceeding the guideline in the individual dairyman's herd. Recently, FDA ordered sampling of all fluid milk for PCBs at the "farm pickup point" in the 50 States. Based on the results of FDA surveys, the overall milk supply does not present a significant health hazard to the general public. There may be a possible hazard, however, to the individual farm family if they consume milk produced on the farm. Assuming consumption of one quart of milk per person per day with an average contamination of 7.5 ppm in the fat, an individual could consume as much as 10 mg of PCB per year. Whether or not this level of intake over several years would constitute a health hazard is not known, but a total intake equal to 1/10 of the minimum short-term dose known to produce clinical defects in the Japanese experience could occur in a 5-year period at this rate.

Field and laboratory studies by ASRD indicate that the rate of dynamics of Aroclor 1254 milk secretion is identical to the residue behavior of the DDT metabolite, DDE. Aroclor 1254 is resistant to metabolic degradation, and it is transferred efficiently to milk fat or to body fat. It requires about 6 to 8 weeks to reduce milk residues by one-half after the cow is placed on clean feed. No practical method has been found for speeding up the decontamination of the animal. Charcoal appears to be somewhat effective in the prevention of absorption when fed with PCB-containing silage but has no value in removing body stores.

Cull dairy animals from farms with contaminated silos could be expected to have tissue residue levels of PCB exceeding 5 ppm in the fat. In general, the tissue residue levels would be similar in magnitude to the milk residue levels. Silage is not a significant feed for fattening cattle; therefore, it is probable that no other class of meat would be contaminated from this source.

Practical methods for handling the contaminated silos short of complete abandonment have not been developed. A feasible method would have to cost significantly less than the price of a new silo.

Temporary expedients have been attempted. Since most of the contamination is adjacent to the wall, some individuals have discarded the material within 3 or 4 inches of the wall. ASRD and the University of Kentucky have examined milk from several farms where this was attempted. Residue levels were reduced but did not consistently fall below the guideline.

A plastic barrier installed as the silo is filled shows promise as an effective temporary expedient. Very little PCB penetrates through the barrier; however, as in the case of attempting to avoid the material next to the wall, this method is impractical with mechanical unloading and one cannot be certain that the barrier will be used in future years.

PCBs are quite soluble in a number of nonpolar solvents. Thus, with the appropriate selection of solvent, it should be possible to wash most of the PCBs off the walls. Several silos in Kentucky have been washed with gasoline (very hazardous, even if lead-free). This appeared to remove about 90% of the PCBs from the walls near the top of the silos. A thorough job of washing was not done, however, on the lower parts of the silos; and some milk residue levels were nearly as high in these herds as in untreated herds. This procedure should be studied in a more thorough manner and its economics established.

Another method of removing the PCBs from the silos would be sandblasting. The cost of sandblasting has been established at more than half the price of a new silo

and in many cases would exceed the depreciated value of the existing silo. Sandblasting also creates a significant dust problem; thus, it is possible that one would remove the PCBs from the silo wall but spread it to the other areas around the farm.

2. Poultry

Rehfeld et al. (1971) have recently reported that the maximum tolerance of chicks to PCBs, containing 48% chlorine, is approximately 50 ppm in the diet. Symptoms observed in chicks fed PCBs included depressed weight gain, edema, gasping for breath, hyperpericardial fluid, internal hemorrhaging, depression of secondary sexual characteristics, and an increase in liver as a percent of body weight. Several of these symptoms were present when levels of more than 20 ppm of PCBs were fed.

Scott et al. (1971) fed four levels (0.5 to 20 ppm) of Aroclor 1248 to White Leghorn hens for 8 weeks and measured the effect on egg production; egg breaking strength; fertility; hatchability of fertile eggs; feed consumption, and PCB content of eggs, adipose, and other tissues. No effect was observed on feed intake, breaking strength of eggs, or fertility. Egg production was reduced 10 and 13% after 8 weeks when 10 and 20 ppm of PCBs, respectively, were fed. At these levels, the eggs contained 3 and 7 ppm, respectively.

The two lowest levels of dietary supplemental PCBs, 0.5 and 1.0 ppm, resulted in plateau levels in eggs of 0.2 and 0.45 ppm, respectively, and 3.1 and 6.6 ppm in adipose tissue after 8 weeks. The ratio of PCB in eggs compared to that in adipose tissue of the hens ranged from 1:12 to 1:15.

The effect upon hatchability was more dramatic than egg production. The lower levels of 0.5 and 1.0 ppm of PCB produced no effect, but the 10 ppm level of PCB reduced hatchability in 4 weeks to 65 percent, and the 20-ppm level almost completely eliminated hatchability of the eggs. At this higher level, the embryos in eggs died during the 21st day of incubation.

In the Cornell study attempts were made to deplete the hens of PCBs, using high- and low-energy diets; but with both diets, the rate of depletion of the body stores was slow. PCB levels in eggs dropped from 3.1 to 1.6 and 7.0 to 3.4 ppm in 4 weeks. During the same period, levels in adipose tissue dropped from 37 to 21 ppm and 83 to 60 ppm.

After the 8-week feeding test, the skin, muscle, liver, and gizzard of the hens fed 10 and 20 ppm of PCBs were assayed for PCBs after depletion periods of 2 and 4 weeks. The skin, apparently because of its high fat content, had from 12 to 28 ppm of PCBs. After 4 weeks, the PCB content of the whole fresh muscle was depleted to levels below 1.0 ppm in 2 weeks. Values for liver and gizzard were intermediate.

Shutze et al. (1971) collected data on three commercial farm flocks where Single Comb White Leghorn breeders had consumed a feed containing 27 ppm of PCBs from fish meal accidentally contaminated with Aroclor 1242 used in a heat transfer exchange fluid. Hatchability of eggs was less than 0.5 percent when the eggs contained more than 2.3 ppm of PCBs. When the PCB concentration in the eggs from flock A decreased to 1.6 ppm, a 20 percent hatch was obtained. Flock B was subjected to 14 days of starvation to determine the influence of forced molting on depleting rate of PCBs. During this period, the concentration actually increased in the adipose tissue from 20.4 to 38.4 ppm.

A third flock was maintained on an uncontaminated breeder ration, and the PCB content of the eggs and the hatchability of the fertile eggs were monitored weekly. After 2 weeks, the level of PCBs in the eggs dropped to 1.3 ppm; and hatchability was 85%. After one more week, the level in eggs dropped to 1.1 ppm; and hatchability was 92 percent. After 10 weeks of depletion on the uncontaminated diet, the level of PCBs in eggs had dropped from 2.5 to 0.72 ppm and in adipose tissue from 20.4 to 8.6 ppm.

The level of PCBs required to affect hatchability in chickens is much greater than the level which interferes with the reproduction in ranch mink. Coho salmon containing 15 ppm PCBs caused reproductive failure when fed to ranch mink (Auerlich et al. 1971).

Dahlgren and Linder (1971) reported that Aroclor 1254 fed to pheasants at 25 mgs per week for 17 weeks significantly depressed egg production and increased the number of pips. Even though weekly weight changes of hens, fertility and hatchability of eggs, mortality of adults, and egg shell thickness did not appear to be affected by PCBs, total reproductive success was depressed. Mortality of chicks from hatching to 6 weeks of age was significantly greater in the offspring from hens fed 50 mgs of PCBs weekly (Shutze et al. 1971).

Tucker and Crabtree (1970) observed that the acute oral LD_{50}'s for Aroclor 1242, 1254, 1260, and 1268 in the Mallard duck were around 200 mgs/kg or greater. Similarly, Platanow and Funnell (1971) found the LD_{50} to be about 200 to 400 ppm in chicks when fed from day-old for 4 to 13 weeks.

3. Fish Farming

The marked increase in commercial catfish production in the southeastern United States makes the PCB contamination problem of considerable economic importance to this industry. Contamination stems from two primary sources: water and commercial fish food.

Fish have been shown to develop levels of PCBs in their tissues as much as 75,000 fold higher than found in their environment. A temporary tolerance level of 5.0 ppm for fish is proposed by FDA (Federal Register, March 18, 1972). It is estimated that PCB levels in the water cannot exceed .07 ppm without the possibility of exceeding the tolerance. Of course, concentrations should be considerably less than this in order to provide a safety factor since marked variation can occur in levels built up in fish with different lengths of exposure time.

This tremendous ability of fish and other marine life to filter out PCBs from the water and concentrate them in their body fat must be fully considered in the commercial production of fish.

Levels at 3.0 ppm of PCBs, which exceed the proposed guideline of 0.5 ppm for finished animal feeds, have been found in catfish feed, leading to its condemnation by FDA.

The ability of the fish to concentrate PCBs in body fat is greater than that of poultry. Moreover, fish food formulas frequently contain fish meal, feed-grade fat and animal byproducts which could be contaminated with PCBs. The same precautions are needed in formulating suitable fish food as are required for rations for poultry and swine.

The overall problem of PCBs in fish production is likely to be greater than for poultry or swine, however, even if background levels in the feed are low, since both water and feed are potential sources of contamination.

C. Contamination of Food from Packaging Material

The presence of PCBs in paper products was described at a recent meeting sponsored by the Grocery Manufacturers of America, Inc. The primary source of PCBs was found to be carbonless paper which was present in certain grades of paperstock being recycled in the paper industry. The PCBs were used as a component of the dye carrier in the carbonless carbon paper. In many cases, the recycled paper was used in paperboard for packaging food, thus resulting in a contamination of the food.

PCBs have been found in paper and paperboards that did not contain carbonless carbon paper. The American Paper Institute is currently sponsoring a study to determine levels of PCB in United States pulp, paper, and paperboard and to investigate the migration of PCBs from paperboards to foods.

A national survey of PCB contamination of foods from packaging materials was conducted by FDA. The results revealed that even though 67% of the complete food packaging tested contained PCBs at levels as high as 338 ppm, only 19% of the foods in these packages contained PCBs. The average PCB concentration in food was 0.1 ppm, and the maximum PCB level found was 5 ppm. In packaged infant cereal samples, 75% of the food products contained PCBs. The average PCB concentration in the cereal was 0.3 ppm, and the maximum PCB level found was 1 ppm.

The survey shows a continuing and substantial reduction in the PCB concentrations of paper-packaging materials. Currently, 95% of recycled paperboard samples examined contained less than 5 ppm PCBs; data on the same type of material manufactured during 1970 and 1971 shows that only 18% of the samples contained less than 5 ppm.

FDA has proposed a temporary tolerance of 5 ppm in paper food-packaging materials to permit unavoidable PCB residues in these products for a sufficient period of time to provide an opportunity for the orderly elimination of PCB-containing raw materials used in the manufacture of food-packaging materials (Fed. Reg., March 18, 1972).

D. Transfer from Soil to Plants

Although cereal and oilseed products may contain low background levels of PCBs, it is not known whether this is derived from soil-to-plant transfer or is a result of contamination from equipment, dust, or water.

Studies involving DDT uptake from water by Euglena gracilis (de Koning & Mortimer 1971) show that this aquatic organism takes up DDT leaving the PCBs in the culture medium.

It would appear at this time that transfer to plants is not likely to be a significant source of contamination of the food supply; nevertheless, studies need to be conducted to answer this question. According to an FDA report, PCBs have been found in trace amounts in the byproducts from two potato-processing plants.

Sewage sludge is a possible source of contamination when applied to the soil. Analysis of sewage sludge at Fort Collins, Colorado, indicated that PCB content ranges from less than 1 to as high as 12 ppm based on air dry weight. Aroclor 1254 was the primary constituent; lower amounts of Aroclor 1248 and 1242 were found.

E. Analytical Methodology

PCBs can be detected in the environment and all foods by the same basic analytical method used to detect the chlorinated hydrocarbons. Confirmatory procedures require the chemical alteration of the pesticide compounds, usually by alkalization which does not affect the PCBs present.

These highly stable compounds escaped detection in food and environmental samples for a long time because mixtures were present in low concentration and because many of the individual compounds contained in the mixtures have the same retention time on GLC columns as commonly found chlorinated

pesticides, However, as PCBs increased in the environment and more sensitive detectors become available, an unknown contaminant was suspected and proven by Jensen in 1967 to be PCBs.

Recent developments in analytical methodology have greatly improved the analysis techniques for determining PCB residues. Techniques for separation of PCBs from organochlorine residues include the use of silicic acid column chromatography (Armour and Burke, 1970) and PCB separation using charcoal columns (Berg et al., 1972). Gel permeation chromatography has greatly improved separation of PCBs and other organochlorine residues from extracts containing high concentration of lipids (Stalling et al., 1972).

Prior to GLC analysis, the PCBs and polychlorinated terphenyls (isomers and homologues) were converted to perchloro bi- or terphenyl with $SbCl_5$ (Berg et al., 1972). These individual components can be subsequently determined by GLC and offer a means of confirmation of PCBs and a simpler means of quantitation. The use of a chlorine specific detector (electrolytic conductivity or microcoulometric) offers two distinct advantages. They are more specific and permit simple conversion of peak area to micrograms of component as the degree of chlorination and molecular weight of separated Aroclor components are now known.

The identification of the PCBs has proven difficult since the chemical standards are not pure compounds but commercial chemical mixtures. In addition, PCBs are partially metabolized by animals and birds; therefore, tissue residues normally differ from the provided chemical standards.

Traditionally, multiple peak residues have been difficult to accurately quantitate on GLC. Basically, it is a question of how to measure the recorder response when more than one peak is involved. Some chemists prefer to measure the area under individual peaks and other chemists prefer to measure the area under all the peaks. It has been proven that analytical results can be in reasonable agreement between laboratories when analysts in the laboratories use the same extraction procedures and methods of quantifying the residues detected.

IV. Monitoring the Wholesomeness of the Food Supply

The average person in the United States consumes about 1,450 pounds of food each year. This represents a total annual consumption of almost 300 billion pounds of food at a cost of approximately $128 billion in 1971. It is estimated that approximately 25,000 companies are involved in food production in the U.S. at the present time. Moreover, about 10 percent of our total food supply is imported. Accordingly, a monitoring program designed to provide maximum assurance of wholesome food to all consumers is essential.

A. Background Levels in Foods and Feeds

In November 1969, FDA began to analyze raw agricultural commodities sampled under the pesticide surveillance program for PCBs as well as pesticide residues. Six hundred eighty-four samples of fish, cheese, milk, shell eggs, and fish byproducts, out of 3,505 samples of these commodities, have been found positive for PCBs. The following report of results is adapted from a talk given by Dr. A. C. Kolbye, Jr., of the Bureau of Foods, FDA:

PCBs were encountered most frequently in fish in 363 of the 670 samples ranging from trace levels to 35.29 ppm. PCBs were detected in fresh water fish including catfish, chubs, and smelt and also salt water species including porgies, sea trout, bluefish, bonita, and sardines.

PCBs in Selected Food Commodities
7/1/70 to 9/30/71

Commodity	No. of Samples Examined	No. of Samples Positive	Percent Positive	PCB Levels (ppm) Low	High	Average
Fish	670	363	54	T*	35.29	1.87
Cheese	1344	91	6	T	1.00	.25
Milk	941	69	7	T	27.80	2.27
Shell Eggs	550	161	29	T	3.74	.55
Fish Byproduct	-	13	-	T	5.00	1.17
TOTAL (Excluding Fish Byproduct)	3505	684	19			1.14

* T indicates "trace."

The above results reflect both surveillance and compliance samples. Average residue levels do not include values indicated as "trace," which in normal analyses would be less than approximately 0.1 ppm for fish; 1-1.5 ppm for milk or cheese fat; and 0.2 ppm for eggs.

The FDA total diet studies representing a total of 900 composite samples analyzed for the past 2½ years show 54 composite samples to contain PCB residues ranging from a trace to 0.36 ppm. These positive findings were found in meat, fish, poultry, dairy, and cereal composites. The 0.36 ppm PCB value reported in the total diet study was found to be caused by migration of PCBs from the grayboard container and dividers to packaged shredded wheat. Subsequent information gathered on the occurrence seemed to point to the use of reclaimed or recycled paper in the manufacture of the cardboard packaging material used for these packages. Other analysis of complete diets considered typical of foods consumed by lower socioeconomic groups of the Southeastern United States (Price et al., 1972) revealed trace levels of PCBs in four diets and levels of 0.20, 0.42, 0.58, and 0.84 milligrams per day per subject in four other diets of preadolescent girls.

No PCBs have thus far been reported in fresh fruits and vegetables.

The data available to date from an FDA survey to determine levels of PCBs in animal feeds show that of 1,274 samples of feed manufactured for various livestock and poultry species, only 4.4% were positive for PCBs (Feedstuffs, March 20, 1972). Levels range from no detectable contamination to a maximum PCB level of 0.6 ppm; hence, finished animal feeds seldom exceed the temporary tolerance of 0.5 ppm set by FDA. PCB contamination of feeds for food-producing animals can generally be attributed to avoidable industrial accidents and practices.

FDA has proposed temporary tolerances for foods and feeds as follows (Federal Register 37(34) March 18, 1972):

	PPM
Milk (fat basis)	2.5
Dairy products (fat basis)	2.5
Poultry (fat basis)	5.0
Eggs	0.5
Finished animal feed	0.5
Animal feed components (including fishmeal)	5.0
Fish (edible portion)	5.0
Infant and junior foods	0.1
Food-packaging material	5.0

B. Inspection and Control

The objective of an inspection program is to insure acceptable quality and wholesomeness of food for the consumer. Materials that are toxic or otherwise present a hazard to health must be identified and eliminated to the maximum extent possible. The extent to which these objectives can be attained depends to some degree upon the authority of the inspection agency and the availability of funds and personnel to carry out an effective monitoring system. There are, of course, many interrelated areas of concern that must be considered in the total program such as:

1. Identifying the hazard
2. Locating the source of contamination
3. Corrective action needed
4. Developing an appropriate sampling procedure
5. Appropriate assay methodology
6. Disposition of contaminated products

It has been suggested that the attributes of food fall into two general categories; namely, those which are sensory and are normally detected by appearance, taste, odor, etc., and those which are hidden and require special methods of detection since they escape detection by the consumer's senses. This latter category is of increasing importance as far as the consumer's health is concerned since so many toxic substances fall into this class.

The most critical problem is detecting those contaminants that creep into the food supply through accidental contamination from environmental sources. The most effective approach in the case of substances such as PCBs is to concentrate on the known or suspect sources and perform nearly 100% sampling to assure detection of contaminated products.

The matter of disposition of suspect or known contaminated lots merits consideration. In many cases, this requires detention of the food pending a segregation of "good" and "bad" lots when such action is feasible and disposition of affected portions according to guidelines prescribed by the regulatory agency.

In any inspection program dealing with contaminated foods, the objective is, of course, to protect the health of the consumer by removing contaminated products from the market. Further objectives are to attack the source of contamination, to eliminate it completely, and to develop an appropriate surveillance program.

This is frequently accomplished by placing the primary control responsibility to the fullest extent on the industry concerned. Two regulatory agencies, namely the Meat and Poultry Inspection Program of the USDA and the Food and Drug Administration, are charged with maintaining a wholesome U.S. food supply. The officials in these agencies and the Congress recognize that more protection is offered by controlling the ingredients going into foods than by depending on the procedures for testing the final products. The mere volume and diverse sources of foods used in the United States limit finished product testing to an assurance program.

To meet their responsibilities in the nonvisible toxic substance area, both USDA and FDA use the same basic procedures. Both require prior approval of food additives and materials for use in direct contact with food and both use laboratory surveillance for toxic residues which may occur in the raw agricultural product prior to processing. To minimize this, pesticides or other potentially harmful chemicals used in agricultural production are restricted as to amount used or residue remaining in or on the raw agricultural product.

Such procedures have not provided protection from environmental contaminants and unintentional inclusion of certain industrial-type chemicals in the food supply.

C. The Cost of PCB Accidents to Agriculture

The accidental contamination of animal feed with PCBs, such as that resulting from heat transfer fluid leaking into fish meal, imposes without warning an enormous economic and psychological burden upon the user industry, as well as the control agencies. Such an incident requires (1) extensive sampling of feedstuffs to prevent future use if found contaminated; (2) extended holding of food animals where contamination is suspected; (3) analysis of samples of all possibly contaminated meat animals at the time of processing by the inspection agency to protect the consumer; (4) selected samples and analyses of animals during

the production phase by the producer to insure early detection of contamination, if any; (5) modification of management, purchasing, and marketing practices as required; and (6) disposal of condemned animals and feedstuffs.

As an example of direct costs, the occurrence of PCBs in the chickens affected in the Maine incident resulted in a total cost to the agricultural community of at least $1,351,000. Laboratory analysis of 502 samples cost the Meat and Poultry Inspection Program (MPIP) of USDA, $12,278. Mailing charges on these samples totaled $6,024. The inplant inspectors spent 251 hours collecting the samples at an approximate cost of $900. In addition to these accountable costs, the travel and supervisory expenses are estimated at $4,000. The total cost of the Maine incident to MPIP is at least $23,202. The cost to the producers can be estimated only from the number of broilers, approximately 1.3 million, which had to be destroyed. At an average weight of 3.5 pounds, at 29¢ per pound, the loss to the producers was $1,326,000 plus the cost of the laboratory analyses for precertification. The Maine incident was, of course, only one of several which occurred in the poultry industry.

In addition to these direct costs to the industry and to State and Federal control agencies, the intangible loss to the industry from reduced confidence in the food product by potential consumers may be considerable. In view of these large and unexpected costs, it seems obvious that efforts should be developed for monitoring potential hazards before they become serious problems to the industry.

D. Surveillance of Feeds and Raw Food Products for Potential Hazards

Since the agricultural community must continue to produce and process foods in a way that assures safety to the consumer, USDA should devise a method to identify potential problems and develop solutions for implementation before such problems reach the proportions of the problem of PCBs in the food chain. This will require an effective "early warning" surveillance system for hazardous substances as they relate to Agriculture's responsibilities--the production, processing, and marketing of foods and food products. To be most helpful to agriculture and to the

consumer, such a surveillance system should provide the basis for technological assistance in cooperation with States and regions to correct or prevent a problem and, as far as possible, should not be the primary responsibility of the agencies responsible for corrective action. To make this surveillance system effective, the following will be needed:

1. Identification of specific problem areas which should receive primary attention.

2. Appropriate methods of sampling animal feeds, soils, water, and food products to study the extent of a particular problem.

3. Suitable laboratory analysis for the environmental residues, pesticides, feed additives, or microbial contamination. This service should be provided at the State level and every effort made to keep it from being involved with regulatory activities so as to encourage industry cooperation.

4. Routine, up-to-date evaluation and exchange of information on each critical facet of food safety.

This effort by Agriculture would build on information collected by FDA, EPA, and by the USDA meat, poultry, and egg products inspection program; but more directed effort must be given to potential problems if we hope to prevent them through modified or improved technology. This is the broad responsibility of Agriculture if it is to continue to fulfill its purpose.

With respect to continued surveillance of PCBs, the major points at which PCBs enter the food chain should be identified so that corrective procedures can be implemented to prevent the problem. Surveillance efforts should be concentrated on feed ingredients of animal origin and other likely sources of contamination such as silage, etc.

V. Needs in Agriculture

The Interdepartmental Task Force on PCBs comprised of five Executive Branch departments has taken action to:

--Restrict the discharge of all industrial effluents of PCBs from PCB users into water so that levels of PCBs in rivers or lakes do not exceed 0.01 parts per billion. (Environmental Protection Agency)

--Propose new regulations for more stringent action levels for PCBs in foods, prevent PCB contamination in food packaging materials, prevent contamination of food from accidents in food plants. (Food and Drug Administration)

--Support the Toxic Substances Control Act pending before Congress in order to provide additional regulatory authority needed to control the use and distribution of PCBs, to control imports, and to collect information.

The Interdepartmental Task Force on PCBs has recommended that only essential uses of PCBs--in electrical capacitors and transformers--be continued. Even with all nonessential uses of PCBs discontinued, the levels already found in fish, wildlife and certain animal feedstuffs will require continued surveillance due to the persistent nature of PCBs and their already widespread occurrences in the environment (Nisbet and Sarofim, 1972).

In examining the PCB problem, the USDA Ad Hoc Group on PCBs considered the broad implications of environmental contaminants entering the food supply, especially as it relates to the need for surveillance. The following recommendations pertain to the vital interests of agriculture:

A. For Immediate Attention

1. Identify the number and location of concrete silos contaminated with PCB-containing paints or sealants.

2. Determine practical methods of correction by clean-up or possible replacement of contaminated silos.

B. For Priority Attention

1. Surveillance on PCB content of foods and feeds and feed components of animal origin.

2. Quantitation of the retention and excretion of PCBs by food animals and a study of those factors which influence each, especially in animals which consume large amounts of feed per unit body weight.

3. Determine the degree of uptake of PCBs by plants and the relative significance.

4. Improve methodology for the extraction, identification, and quantitation of PCB residues.

C. Other Informational Needs

1. Determine degree of synergism or additive effects of PCBs with other toxic substances, especially pesticides.

2. Determine the biodegradation and photodegradation products of PCBs and their implication in the food chain.

3. Determine toxicology of pure chemical forms of PCBs.

4. PCB content of materials used for packaging and factors affecting their transfer to food.

5. Methods of detoxification or removal of PCBs from feeds and foods.

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APPENDIX I

SURVEY OF RESEARCH

IN AGRICULTURE*

	AIR	WATER	SEWAGE	SOIL	BIOLOGICAL	MOVEMENT	TOXICOLOGY	RESIDUE	ANALYTICAL METHODOLOGY	BIOLOGICAL MAGNIFICATION	FIELD STUDIES	LABORATORY STUDIES	SCIENTIFIC MAN-YEARS	SUPPORT MAN-YEARS
Adams, R.S,Jr. Univ. of Minn.	x							x			x			
Aue, Walter, Univ. of Mo.		x							x			x		
Bevenue, Arthur, Univ. of Hawaii		x	x					x	x		x	x		
Bowman, M.C., USDA-ENT-PCRB									x			x	0.1	
Britton, Walter M., Univ. of Ga.					x		x	x	x		x	x	0.2	0.5
Cox, H.C., ENT-ARS									x					
Crosby, D.J., Univ.of CA, Davis											x	x	0.1	0.2
Dahm, Paul A., Iowa State Univ.								x			x		0.1	
Dorough, H.W., Univ. of Kentucky									x			x		
Fish, R.C., ARS, Kerrville, Tex.					x		x	x	x	x		x	.25	2.0
Geer, R.D., Montana State Univ.									x			x	0.2	0.7
Gunther, F.A., Univ. of CA,Rivers.								x	x			x	0.5	1.5
Hall, R.C., Purdue Univ.									x			x	1.0	
Hill, K.R., ENT-USDA		x		x	x			x	x		x	x	0.5	
Johnsen, R.E., Col. State Univ.		x	x	x				x	x		x		.3	.3
Kearney, P.C., ARS-USDA, Beltsvll												x	.5	.5
Lichtenstein, Paul, Univ. of Wisc.						x	x			x		x	1.5	2.0
Lisk, P.J., Cornell University							x	x				x	1.0	1.0
Nakatsugama, T., NY State, Syracuse								x		x		x	.3	.6
Newsome, L.D., La. State Univ.					x	x	x			x		x	0.1	0.1
Olney, Charles, Univ. of RI						x		x	x	x	x		.3	.5
Olson, O.E., SD State Univ.								x		x	x	x	.5	.5
Peakall, D.B., Cornell Univ.							x					x	.5	..5
Plapp, F.W., Jr., Texas A&M						x	x					x		
Sheets, T.J., N.C. State					x			x	x			x	0.1	0.1
Stut, J.C., Utah State Univ.								x	x			x	0.1	0.1
Van Middelem , Univ. of Fla.				x	x				x		x			0.1
Ware, G.W., Univ. of Arizona								x	x		x			0.1
Warwick, E.J., ARS, Beltsville							x	x		x	x	x	1.0	1.0
Willett, L.B., Ohio State, Wooster					x	x	x	x			x	x	1.5	0.5
Young, R.W., VPI, Virginia					x			x	x		x	x		

SURVEY OF RESEARCH IN AGRICULTURE

Adams - Looking for DDT, chlorinated hydrocarbons, and PCBs in rainwater.

Bevenue - Working on analytical method to determine residues in water and sewage.

Bowman - Working on method to separate from DDT and DDE.

Britton - Studies are being conducted to determine the levels of several of the PCBs which influence hatchability when added directly to the egg or when added to the diets of laying hens. Tissue and egg residues are being analyzed.

Cox - (1) Developed a method using chromous chloride reagent to distinguish toxaphene from PCBs, singly or in mixtures, in any substrate, but primarily in water.

(2) Tables of "p-valves" in several solvent pairs were determined for all visible GC peaks from five commercial Aroclors in order to provide an additional confirmation procedure for distinguishing pesticides from PCBs. Although different "p-valves" were obtained for p,p,-DDE and the PCB peak having the same GC retention time, the standard deviation of the method permitted too much overlap for reliable confirmation.

(3) During the analysis of 111 egg product samples thought to be contaminated with PCBs, it was found that a simple hexane solution from a Florisil column would separate PCBs from naturally occurring interfering substances in the eggs.

Crosby - Study the effects of sunlight on PCB when suspended in water and hydrocarbons. Found that there is a breakdown of PCBs.

Dahm - Several mink have been collected in the Iowa area and analysis of fat, brain, and liver for PCBs and chlorinated hydrocarbons will be made. Levels will be correlated with age.

Dorough - Found PCBs (Aroclor 1254) in sealant in silos. The milk from cows eating this silage contained levels of PCBs in excess of that considered safe by FDA.

Fish - Research is in progress on farm animals consisting of 2-year-old sheep (male and female) and 7- to 11-week-old chickens (male and female) at dosages of 10 to 100 mg/kg. daily for 21 days for chickens and dosages of 25 mg./kg. daily for 71, 95, and 100 days for sheep. Three different types of Aroclors were used for sheep and three different types for chickens.

Geer - Synthesized 30 PCB isomers and developing a voltametric method for directly identifying individual PCB isomers and chlorinated compounds.

Gunther - Studying the persistence of PCBs in various soil types which are incubated at constant environmental conditions. Also working on analytical methodology.

Hill - Working on methodology to separate PCBs from DDT, DDE, and toxaphene.

Kearney - Isolate microorganisms capable of metabolizing biphenyl and determine the effect of chlorine substitution on the rate of metabolism.

Lichtenstein - Investigated toxicity of dieldrin and DDT with and without 11 different PCBs. As the chlorine content of PCBs decreased, there was an increase in toxicity. When the PCBs were added to the organochlorine insecticides, there was a synergistic action.

Lisk - Analyses of PCBs in newspaper and cardboard which may be used to feed cattle as a source of cellulose. Plans are to look at milk from cows which are fed recycled paper containers.

Nakatsugama - Study the phenomenon of biological magnification analytically. PCBs will be used as one of the test compounds.

Newsom - Ducks and chickens were fed a diet containing 100 ppm of PCBs (Aroclor 1221) or a diet containing an organochlorine pesticide. When fed to chickens, PCBs had no statistically significant effect upon eggshell thickness or strength, number of deformed eggs, egg production, or carbonic anhydrase activity of uterine tissue. PCBs at 100 ppm had no effect on shell thickness and hatchability when fed to mallard ducks, but did cause a decrease in shell weight (-8%), calcium content of shell (-9.6%), and egg production (0.05 egg/day).

Olney - Surface waters of Narragansett Bay have shown residues of PCBs at the level of 4 ppb or less. To date, there is little evidence of any specific Aroclor in fish, sediment-water samples from streams and ponds of Rhode Island.

Olson - Studies have been carried on concerning the PCB levels in tissues and eggs of wild cormorants and pelicans and their foods and environment. Attempts were made to assess the effects of these compounds, mercury and chlorinated hydrocarbons, on the nesting failures of these birds. The storage and deposition of PCBs by pheasants have also been looked at, and eggs were found to be an important way of excretion.

Peakall - Determined the physiological effect on birds at 10 ppm of Aroclor 1254. No mortality was found in the first generation but heavy mortality in second (embryonic). No eggshell thinning or shell breakage.

Plapp - Using houseflies, demonstrated that the polychlorinated biphenyl mixture, Aroclor 1254, acts as a synergist with carbaryl. The mechanism of synergistic action is unknown but speculation is that it involves the inhibition of microsomal oxidase which is usually responsible for insecticide synergism.

Sheets - Routine analyses of eggs from hens receiving Aroclor 1242 in feed at dosages ranging from 0.3 to 2.5 ppm. Have not been successful at this time in separating PCBs from DDT and degradation products.

Stut - Hepatic microsomal enzyme induction in rats was evaluated using the entire Aroclor series 1221 through 1268 with 4465 and 5442. The materials were fed to female rats in concentrations from 25-100 ppm for 15 days. Induction potency of enzymes was highly correlated with the percentage chlorination of the biphenyl. All the materials, except 1221, caused marked liver enlargement.

Van Middelem - Looking at levels in brown pelicans and the fish consumed by pelicans.

Ware - Working on methodology. Attempting to codistill PCBs with water.

Warwick - Eleven PCB and PCT materials were tested to determine their estrogenic activity in rats. All of the compounds containing up to 50% Cl were found to be active, while compounds containing higher amounts of Cl were inactive.

Aroclor 1242 was extensively investigated in rats and Japanese quail and caused an increase in liver weight and liver lipids and lowered liver vitamin A concentration and content.

Aroclor 1254 has been used in silo coatings. ...In a detailed study of one herd, the rate of elimination of PCB residues from milk followed approximately the same kinetics as DDE. Treatment with activated carbon and/or phenobarbital did not enhance the rate of PCB elimination from cows.

Willett - Research objective is to eliminate PCB residues from a contaminated dairy herd by (1) covering PCB coating in silo; (2) elimination of fat pools in dairy animals; and (3) centrifuging milk to remove fat-soluble PCB contaminants.

Young - Analyzed PCB levels in diets, feces, and urine samples of preadolescent girls fed diets typical of low-income families. Also checked levels in paper bags, marking tags, turkey fat, heavy fowls, eggs, and poultry feeds.

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